Waves	**Stationary waves in air columns**

Learning objectives	**MUST (6)**	Explain the shape of stationary waves in air columns
	SHOULD (7)	Recall the harmonics for air columns with one or two ends closed
	COULD (8/9)	Explain how to use harmonics to find the speed of sound

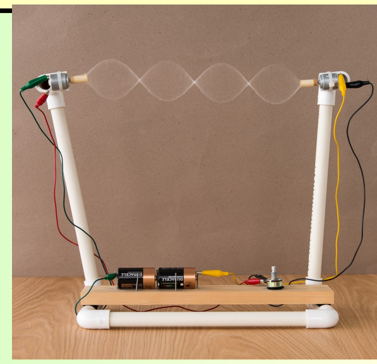
STARTER: Steven Spielberg asked a visual effects designer to make concentric rings of vibrations in water in a cup for a famous scene in Jurassic Park. It was much more difficult than they expected (no, they didn't use CGI). How would you try to make these vibrations?

EXTENSION: What, exactly, do you think is vibrating here?

How the water ripples were created

Waves	**Stationary waves in air columns**
MUST (6)	Explain the shape of stationary waves in air columns

In a previous lesson we looked at waves on a string, with a fixed point (node) at either end. We know that the distance between two nodes (or two antinodes) is half λ, where λ is the wavelength of the progressive waves that are interacting. We can therefore use harmonics to find the speed of the wave.



If the string here is 50cm long and the oscillations are at 200Hz, at what speed do waves travel along this string?

$2\lambda = 0.5$m so $\lambda = 0.25$m, $f = 200$Hz: $v = f\lambda = 50$ m/s

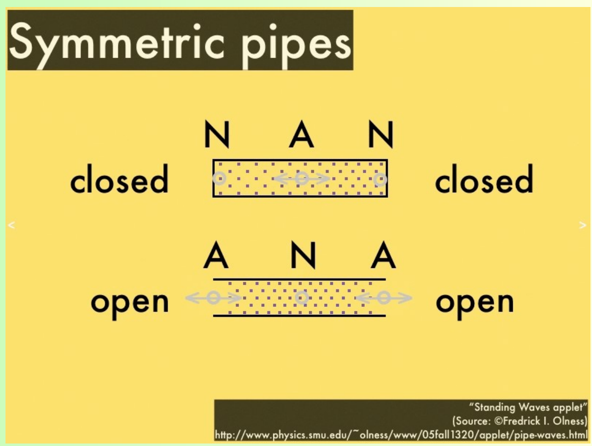
Stationary waves in air columns

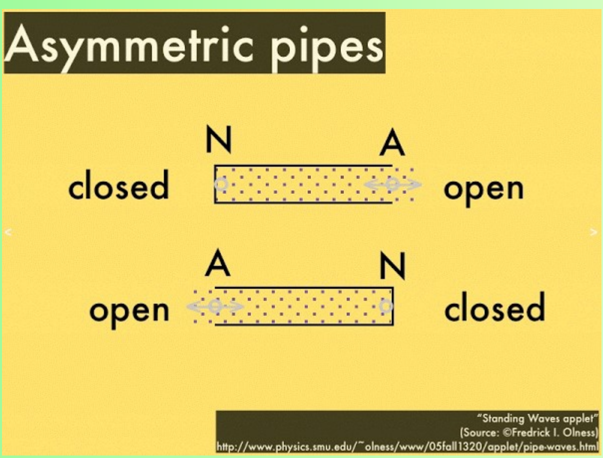
Columns containing air (or another gas) can also form standing wave patterns; this time, the waves are longitudinal. The antinodes, as before, represent particles with maximum amplitude, and nodes represent particles that do not vibrate.

Columns can have **closed** or **open** ends. These are the fundamental modes for different types of column:

At a closed end, there is a **node**, as the air there is not vibrating.

At an open end, the vibrations are at a maximum, so there is an **antinode**.



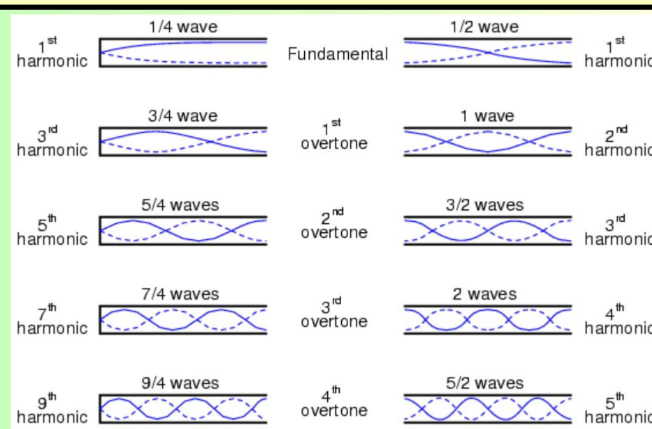


An asymmetric pipe has one closed end (node) and an open end (antinodes).

Waves	**Stationary waves in air columns**
SHOULD (7)	Recall the harmonics for air columns with one or two ends closed

When working out the harmonics, remember each open end is an antinode and each closed end is a node.

As before: the distance between each node is λ/2, where λ is the wavelength of the progressive wave.

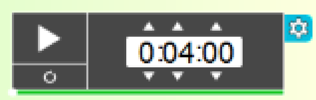


Stick in the chart. Why doesn't the closed-ended pipe have a 2nd or 4th harmonic?

Extension: Which has a higher sound: a pipe open at both ends, or an identical pipe with one end closed?

4 The air column inside an open tube is made to vibrate at $2f_0$, where f_0 is the fundamental frequency. Identify the nodes and antinodes in Figure 6 below. *(5 marks)*

▲ **Figure 6**

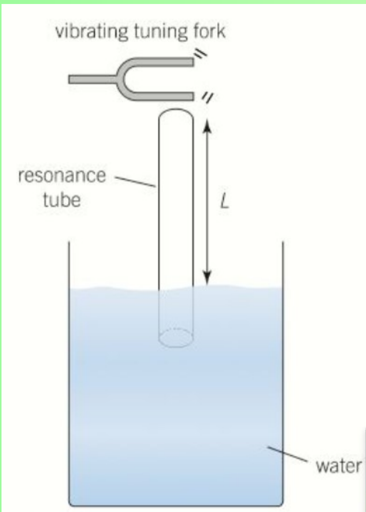


Nodes: B and E [2]

Antinodes: A, D and G [3]

(1 mark for each correctly identified. Deduct 1 mark for each incorrect letter, minimum mark = 0)

Waves	**Stationary waves in air columns**
COULD (8/9)	Explain how to use harmonics to find the speed of sound



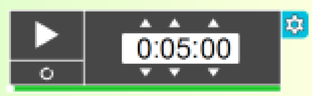
If you know the wavelength and the frequency, you can find the speed of sound in a medium.

A tube in water is a tube with one closed end. If you hold a tuning fork above it, and move the tube up and down, you will find a point at which the sound gets much louder; this is the fundamental frequency.

What is the relationship between L and the wavelength?

$L = \lambda/4$

You know the wavelength of the wave, and the frequency of the tuning fork, and $v = f\lambda$.



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Waves		**Stationary waves in air columns**
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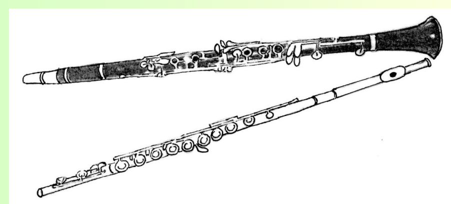
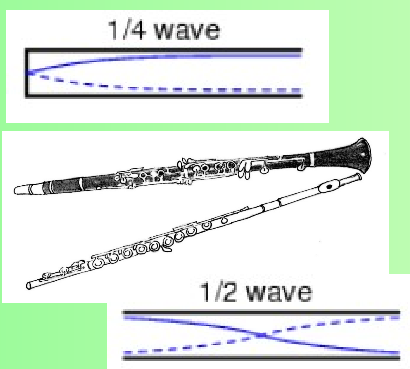
PLENARY: A flute and a clarinet are about the same length. Why is a flute higher-pitched?





Clarinet: 1/4 wave (closed at one end)

Flute: can fit in 1/2 wave (open at each end)

So wavelength in flute is smaller; speed is the same, so frequency must be greater, and the pitch is higher

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